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SALES hereby certify that annexed is a true copy of the Provisional specification
in connection with Application No. 2002950444 for a patent by INTERAD
TECHNOLOGY LIMITED as filed on 29 July 2002.

WITNESS my hand this
Seventh day of August 2003

J. Billingsley

JULIE BILLINGSLEY
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PROVISIONAL SPECIFICATION

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Invention Title: **Bi-directional programming system/method for program
development**

The invention is described in the following statement:

Bi-Directional Programming System/Method For Program Development

5 Technical Field

The present invention relates to a new type of system or method for developing programs (i.e. software applications), and in particular, to a bi-directional programming system or method for assisting a user/programmer to develop computer programs.

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Background Art

The concept of describing programs as flowcharts has been used since the invention of structured programming languages. Originally, these flowcharts were simply drawn on paper to reflect the design that the programmer intended to follow when implementing the
15 program. More recently, flowchart drawing applications have been created thereby allowing a programmer to create digital documentation for their program, prior to implementation.

20 The basic flowchart element in such a drawing application is described as an abstract data type, or class. These drawing applications have generally been implemented using the following basic algorithm:

```
25      struct Element {  
          ElementType type;  
          Rect coords;  
          ElementPtr prev;  
          ElementPtr next;  
          VoidPtr userData;  
30      String description;  
          String comment;  
      };
```

Where ElementType is defined as:

```
enum ElementType {  
    StartFlowchart, EndBlock, CallableStatement, IfClause, ElseClause,  
    SwitchClause, CaseClause, StartRepeat, StartWhile, StartFor  
};
```

The flowchart elements are constructed in a doubly linked list, with the option of an alternate link to represent an "else" condition. The element type defines the drawing algorithm necessary to create any given flowchart element. A flowchart data type can now be constructed by building a container to hold an ordered collection of flowchart elements.

Using this system, it is possible to provide an abstract view of some programming problems. However, in order to provide a more detailed implementation of the actual program being developed, a programming syntax (code) is used, and is compiled into a machine code format.

A computer system understands instructions provided to it as binary numbers, where each given binary number represents an instruction, and each such instruction is of a given length, with the binary numbers following the instruction being the parameters to the instruction. It is unusual and difficult for people to understand or program a computer in binary code. For this reason, high level languages were developed. High level languages aim to allow people to program computers in a language that more closely mimics the English language. Unfortunately, the English language cannot be expressed mathematically, and furthermore, contains enough contradictions in meaning that a computer cannot possibly be expected to understand common English language. So, just as with spoken/written languages, computer languages utilise a system of grammar. The prerequisite for any given computer language is that it is "parsable" (i.e. a computer algorithm can be developed to represent the meaning of the language in mathematical terms).

The flowchart illustrated in figure 1 (prior art) describes a presently known basic parsing algorithm for converting any abstract parsable language (syntactic code) to an

intermediary form (byte code) that can then be converted to machine code (binary code).

5 In the field of program or software application development, programmers have historically used a text-based programming language (code) to pass commands to a computer. This code is terse and often difficult to understand. Typing code can be an error-prone and tedious exercise. In an attempt to somewhat automate the task of coding, several development companies have designed various automation solutions based on using pre-written templates or on using "scripts", which are easier to write and which translate behind the scenes to code. The most outstanding achievement of companies
10 involved in these endeavours was to succeed in creating a system which enabled programmers to build a user interface (UI) (the screens a user sees) by "drag and drop" visual methods. Code could then be automatically generated from the visual interface created by the "drag and drop" methods.

15 Presently, however, once the user interface is constructed, it is still necessary to type further code to actually make the program (i.e. the software application) do something other than act as a user interface. This part of programming is often referred to as "back-end logic building".

20 It is presently known to provide a system for developing a user interface whereby a programmer is enabled to not only build a visual user interface and generate code from it, but also to then modify or add to the code and have the changes or additions reflected in the visual representation of the user interface. This is often referred to as "round-trip engineering" or "bi-directional programming". For example, Microsoft Corp.
25 commercialised such a concept in the product known as Visual Basic. However, it is most important to understand that such presently known technologies apply only to the construction of a user interface and not to back-end logic building.

30 As with most devices we buy, computer User Interfaces represent a static state within the machine or programme. Therefore, each interface within a program is representable as a static image. In the simplest case, it would be quite easy to represent program interfaces as a series of bitmap pictures, which the operating system is able to divide into the appropriate sections based on the coordinates of the mouse at the time an event occurred.

However, this would incur a very significant amount of CPU time. To overcome this, an interface is defined as components which have a static (graphical part) and a dynamic (logic) part. For example, a button could take on many forms graphically, but our main interest in the button is when it is pressed, or released. This is known as an event.

5

A GUI designer such as that used by Visual Basic or Delphi, cannot remember, from one session to the next, which event a button is supposed to execute when it is pressed, or the position or dimensions of the button. To facilitate this, a file is written to disk which contains 'hints' to the IDE as to how to draw a button, and what should happen if it is pressed. This is known as a script. Systems such as Visual Basic and Delphi, contain their own proprietary scripts for this purpose. However, there are standard script definitions available. Some of the more well known ones are HTML, XML and Postscript. Note, that the layman's term 'scripting languages' is not used here, as the scripts generally do not represent a parsable language. In situations where the script is parsable, there is generally no concept of timing available (for example, HTML has no If/If-Else or Loop constructs available etc).

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US Patent No. 5,911,070 (Solton et al.) discloses a development system with visual designer tools for generating and modifying program code. A user employs the visual designer tools to visually create an application program and generate a source file. The user can proceed to edit the source file with a text editor and then return to the visual designer tools at any time to edit a form visually. The user can use both techniques interchangeably, changes which occur in the visual designer tools are reflected in the generated source code and vice versa. However, Solton et al. is only directed to the construction of a user interface and does not disclose a general means for round-trip software engineering as it more broadly relates to back-end logic building of a complete and functional program.

30

In contrast, however, a true visual programming language must by definition, be able to represent a 'program' visually. A static script contains insufficient data to model the final solution. Graphical user interface development tools, like those provided with many modern compilers including Microsoft Visual C++, include highly visual components, but they are more graphics applications and template generators than actual programming languages.

Several types of Visual Programming Language (VPL) exist, as a result of multiple attempts to resolve the specific problems presented in trying to represent a series of time-sequenced events and actions visually. The various types include:

5

1. Purely visual languages: those which create a graphical environment in which the entire development and testing process is performed, and require the compilation of the program within the visual environment. These systems use proprietary "objects", or blocks of pre-written code represented by graphical elements. The programmer assembles the application by arranging the objects in a sequence. Each object calls its related code. The code is not modifiable by the programmer in any way, and the quality of the compiled application is wholly determined by the quality of the pre-written code objects and the ability of the programmer to select and assemble the objects in the appropriate sequence.
- 15 2. Hybrid text/graphics systems, which generate code from graphical diagrams.
3. Programming-by-example systems, in which the programmer creates and manipulates graphical objects to "teach" the system how to perform a task
- 20 4. Constraint-oriented systems, used for simulation design, in which the programmer models physical objects as objects in the visual environment which are subject to constraints designed to mimic the behaviour of natural laws, like gravity.
- 25 5. Forms based systems, broadly based on spreadsheet concepts, which represent programming as altering a group of interconnecting cells over time to allow the programmer to visualise the execution of his program as a sequence of different cell states.

The VPL systems listed above fall into one of two categories:

- 30 1. Stating modelling (i.e. "forms based" visual languages such as Visual Basic), which use graphical objects only to represent static states within the program, and therefore require the interspersation of a text based language in order to provide run-time activity. These languages do not attempt to facilitate the use of graphical elements to represent actions which occur in real-time.

2. Specialised modelling tools (eg. Sketchpad, Thinglab, ARK, etc), which provide 'canned code' style graphical objects to represent constants within our physical environment. As all fields of science contain absolute constants, this premise could be used to provide a modelling environment for many situations. Another example is tools such as Rational Rose, which use the same logic to model business processes/logic. As above, because the graphical elements are modelling static or constant states, the 'program' logic must be built using conventional code.
- 10 The graphical view for existing VPL's is not parsable. Hence, no presently known system truly provides round-trip engineering or bi-directional programming for back-end logic building of a general program.

This identifies a need to provide a new system or method for facilitating round-trip software engineering using flowcharts for use in back-end logic building of a program. This also identifies a need to provide a new system or method for a bi-directional programming system or method for assisting a programmer to fully develop a program which is not only a user interface. This also identifies a need to provide a new system or method for a bi-directional programming system or method where the graphical view is parsable.

Disclosure Of Invention

In a broad form, the present invention seeks to provide a new system or method for facilitating round-trip software engineering utilising a visual representation for use in the back-end logic building of programs. In a further broad form, the present invention seeks to provide a system or method to facilitate back-end programming by providing that (a) editing at a source code level is automatically interpreted as edits in a flowchart representation which is correspondingly updated, and/or (b) existing code for back-end logic building can be read into a flowchart representation. This provides a means for a programmer to modify or add to back-end source code, as opposed to simply user interface code, which can then be automatically converted to a visual flowchart representation.

The present invention also seeks to provide a bi-directional programming system to allow a programmer to enter source level instructions into a computer system via either a visual (or graphic) language interface or a traditional syntactic level interface. Irrespective of which means is used to initially describe the program, a corresponding "view" of the program (visual or syntax) can be generated. Changes to the program can be made at either level, allowing the regeneration of the corresponding view (visual or syntax) to reflect the changes. For example, should the original program be described in a visual or graphical format, then a program with the same meaning can be generated in the corresponding syntax level format. Similarly, if a programmer wishes to make changes to this syntax level, then the equivalent version of the program can be regenerated in the visual view to reflect the changes.

The present invention provides a round-trip software development application for use in back-end logic building of programs in which the graphical view of the program is parsable. Because the graphical view is parsable, the data can be readily modelled using mathematics. This means that any other programming language that can describe the mathematical meaning can also be used for the graphical view. This way, the round-trip is facilitated by simply changing the current view of the program data.

In a particular embodiment of the invention, the underlying syntax level language used is the Java programming language, and the visual or graphic language is described by way of structure diagrams and/or flowcharts. Preferably, structure diagrams and/or flowcharts are used to convey the visual view as most programmers are familiar with first describing a program in this manner prior to commencing the writing of source code. Similarly, the Java language may be used for the syntax view for its platform independence, hence preventing the program from being restricted to any specific operating system.

Brief description Of Figures

The present invention will become apparent from the following description, which is given by way of example only, of a preferred but non-limiting embodiment thereof, described in connection with the accompanying figures, wherein:

- Figure 1 (prior art) illustrates a traditional 'top-down' parsing algorithm;
- Figure 2 illustrates a schematic showing flowchart to code steps;
- Figure 3 illustrates an aspect of the invention showing the complete round-trip or bi-directional cycle;
- Figure 4 illustrates an example of an embodiment of the invention in use – showing an initial flowchart representation;
- Figure 5 illustrates an example of an embodiment of the invention in use – showing the generated code;
- Figure 6 illustrates an example of an embodiment of the invention in use – showing amendments made by a programmer to the code;
- Figure 7 illustrates an example of an embodiment of the invention in use – showing the byte-code conversion;
- Figure 8 illustrates an example of an embodiment of the invention in use – showing the updated equivalent flowchart representation;
- Figure 9 illustrates an example of an embodiment of the invention in use – showing the code generated from the updated flowchart.

Modes For Carrying Out The Invention

The present invention provides a new bi-directional programming system or method for assisting a programmer to develop programs.

I. Preferred embodiment

By forcing a controlled structure to be followed for the input of information, a flowchart allows a program to be described in a manner that more closely resembles either the English language, or whatever natural language a programmer desires to work with. However, in order to maintain a productive work environment, it is necessary to allow the programmer to continue to work in a familiar manner. Hence, the need for a bi-directional programming language allowing the programmer to also enter code.

Where the traditional means of describing a flowchart algorithmically is generally sufficient for documenting, and even in some cases generating function prototypes (headers), these traditional means do not provide sufficient information for generating a complete code based representation of an algorithm. However, by adding certain
5 information to the flowchart element construct (over that which is presently known as discussed in the prior art section), a more complete meaning can be created.

Firstly, the concept of a callable statement is given an index, mapping to a syntax language function call, and any of the five condition type clauses (eg. IfClause,
10 ElseClause,...) is given a condition part. In addition, the concept of a variable is introduced, with the created variables given an index from $0...n$. Where n represents the total number of created variables, minus one. The flowchart description now contains both the collection of flowchart elements, and a collection of variables or symbols, the Symbol Table.

15

This extended flowchart element construct is indicated below:

```

    struct Element {
        ElementType type;
20         Rect coords;
        ElementPtr next;
        ElementPtr prev;
        VoidPtr userData;
        String description;
25         String comment;
    };

    Struct Flowchart {
        ElementPtr StartElement;
30         ElementPtr EndElement;
        SymbolTable symbols;
    };

    struct SymbolTable {
35         Integer symbolCount;
        SymbolPtr firstSymbol;
        SymbolPtr lastSymbol;
    };

40     struct Symbol {
        String name;
        TypeIdentifier type;
    };

```

```
String byteCodeRepresentation;  
SymbolPtr next;  
SymbolPtr prev;
```

```
};
```

5

In a preferred, but non-limiting, embodiment, the remaining programming constructs must then conform to the following rules:

1. A *StartFlowchart* clause can be followed by any other clause, or an *EndBlock*.
- 10 2. A *CaseClause* must always follow either a *SwitchClause* or another *CaseClause*.
3. A *CaseClause* may be followed by either another *CaseClause* (the empty case), or an *EndFlowchart* clause.
4. An *IfClause* must contain a condition part.
- 15 5. An *IfClause* must be followed by either any other clause except a *StartFlowchart* clause, or an *EndBlock*.
6. A *Condition* is defined as "statement; mathematic-condition; statement".
7. A *Statement* is defined as a *Variable* or *ComplexStatement*, where a *ComplexStatement* is a combination of *CallableStatements* and *Variables*, representing a formula that is solvable to a primitive value. In this context, a
20 primitive is defined as either an Integer, a Decimal Number, or a String of characters.
8. Both statements in a condition must resolve to equivalent primitive types.
9. All other conditional constructs (*RepeatClause*, *WhileClause*, *ForClause*) must follow the same set of rules.
- 25 10. A *ForClause* must be followed by two conditional clauses, a start condition and an end condition. Furthermore, the end condition of a *ForClause* must be followed by a *Statement* that resolves to an integer value, to increment the loop counter on each iteration.
- 30 Throughout our daily lives, most everything we do can be broken down into three distinct categories – Problems; Decisions; and Actions. The 'problems' usually arise as a result of a previous action. In programming, this is called an 'event'. The way in which we react to

an event, is known as a 'method' or 'procedure'. Sometimes, a procedure, or part thereof, will need to be repeated a number of times, in order to extract the desired result. This is known as a 'loop'.

- 5 A decision can be described as either:

If (some condition is true), then execute an action. End. OR

If (some condition is true), then execute action A, else execute action B. End.

By allowing the nesting of these constructs, very complex decisions can be represented.

- 10 The final construct required by a programmer is called an 'assignment'. This is the means by which a programmer can insert into a program, a mathematical formula based on known and unknown quantities. The composition of Assignments, Conditions, Loops and Procedures/Methods to arrive at a partial solution to the original problem, is known as an algorithm. A program is then created by analysing the original problem, breaking it down
15 into a number of component problems, defining algorithms for each of these small problems, then assembling the algorithms into a single unit to solve the original problem.

- Using these basic rules, it is possible to describe a flowchart using a string of integer values, otherwise known as byte-code. As referred to for figure 1, byte-code is the
20 intermediary language used to attempt to describe a program when converting syntax level code (source code) to machine code. If there is an error at this byte-code stage, then the compiler can report an error to the programmer as a "syntax error", and the compilation will be aborted.

- 25 By representing the program at this byte-code level, a "view" can be created that describes the program in a manner that humans can more readily understand. The flowchart is considered the most desirable view to use, as this is readily understood by programmers and non-programmers alike.

- 30 The final stages of the traditional compiling process can then be used to convert the code into a machine readable instruction set, however, this is not the purpose of the present invention. Rather, the present invention is concerned, in part, with converting the flowchart byte-code back to the equivalent syntax level code for manipulation by a programmer.

Referring to figure 2, the illustrated flowchart reverses the appropriate compilation steps, to convert the flowchart byte-code back to syntax code. The syntax level code may then be compiled using a standard compiler, or modified at the syntax level and converted back to a visual flowchart representation. At any point, the flowchart byte-code represents the target application accurately enough that it is always able to be compiled, hence satisfying the requirement for flowchart to syntax level code conversion.

Because the code modified by a programmer cannot, however, be guaranteed to be correct, a traditional parsing algorithm must be used to first verify the code prior to attempting to represent it as byte-code (viz. Figure 1).

Once the programmer-modified code has been accurately converted back to byte-code, a flowchart visualisation can be readily re-drawn, or the byte-code may be converted to machine level instructions. The process can be used iteratively, until the programmer decides to output a set of machine level instructions thereby completing the application.

In the interests of simplicity, the final program can be converted back to byte-code, either transparently or deliberately, so that a standard compiler can be used to convert the program to machine code. However, as the program is, by definition, able to be compiled at this stage, the total compile time is significantly reduced.

Figure 3 illustrates the complete process for the present embodiment of a bi-direction programming language.

The following Table I shows basic byte-code language for use in the preferred embodiment.

Byte	Construct	Byte Code Length (bytes)
1	Assignment	4
2	Method Call	3 + 1 byte per parameter
3	If Expression	Variable according to expression, but min 4 bytes
4	If/Else Expression	Variable according to expression, but min 5 bytes

Byte	Construct	Byte Code Length (bytes)
5	For loop	1 + composition of 3 sub-expressions (2 assignments and If condition)
6	Repeat Clause	2 bytes + If condition
7	Do/While Clause	2 bytes + If condition
8	Switch/Case Expression	If condition for start + 1 byte per case. (Nb. Each case task can be viewed as a nested block, expressible by a single procedure call).
9	End Block	1

Table I - Basic Byte Code Language.

Table 1 provides a definition for a byte-code language that can graphically describe a basic visual language. Using this table as the data model of a traditional Document/Model/View program abstraction, a programmer can graphically represent the pseudo-code for any application.

In a particular embodiment, a software implementation of the present invention expands this byte-code, to graphically represent the semantic components of a defined expression. However, using the sample byte-code, this level of abstraction would need to be provided using traditional top-down parser logic (refer to figure 1).

Presented in figures 4 to 9 is an illustrative example of an embodiment of the invention in use. This example should not be construed in any way to be limiting to the scope of the invention presented herein. This example is presented as a series of steps which refer to the figures.

Step 1: (Figure 4) Using a system or program embodiment of the present invention as an application program development environment the initial flowchart representation is created by selecting icons, which represent programming constructs, from a tool bar (not shown), selecting variables from a graphical 'Variable Manager' module (not shown), and entering parameters in response to prompts.

Step 2: (Figure 5) The user selects a 'Generate Java and View Source' menu option (not shown), and the equivalent Java code is generated.

Step 3: (Figure 6) The Java code can then be modified by a programmer, by inserting additional code or making changes to the code. In this example, an addition has
5 been made following the marker "//Inserted Code".

Step 4: (Figure 7) Transparently to the end user, the development system or program converts the code to a byte-code equivalent.

Step 5: (Figure 8) The equivalent flowchart representation, now reflecting the alteration to the Java code made by the programmer at syntax level, is generated and
10 displayed.

Step 6: (Figure 9) From the modified flowchart, corresponding Java code can again be generated and viewed. Note that the "//Inserted Code" marker is no longer present as the code now exactly matches the flowchart from which it was created. Of course, the option exists to graphically modify the flowchart in figure 8 prior to re-generating the Java
15 code, in which case the generated code would reflect any changes made at the graphical flowchart level.

Thus, there has been provided in accordance with the present invention, a bi-directional programming system or method for assisting a programmer to develop
20 programs which satisfies the advantages set forth above.

The invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, in any or all combinations of two or more of said
25 parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which the invention relates, such known equivalents are deemed to be incorporated herein as if individually set forth.

30 Although the preferred embodiment has been described in detail, it should be understood that various changes, substitutions, and alterations can be made herein by one of ordinary skill in the art without departing from the spirit or scope of the present invention.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

5 Dated this 29th day of July 2002
inteRAD Technology Limited
By Its Patent Attorneys
DAVIES COLLISON CAVE

(Prior art)

Figure 1

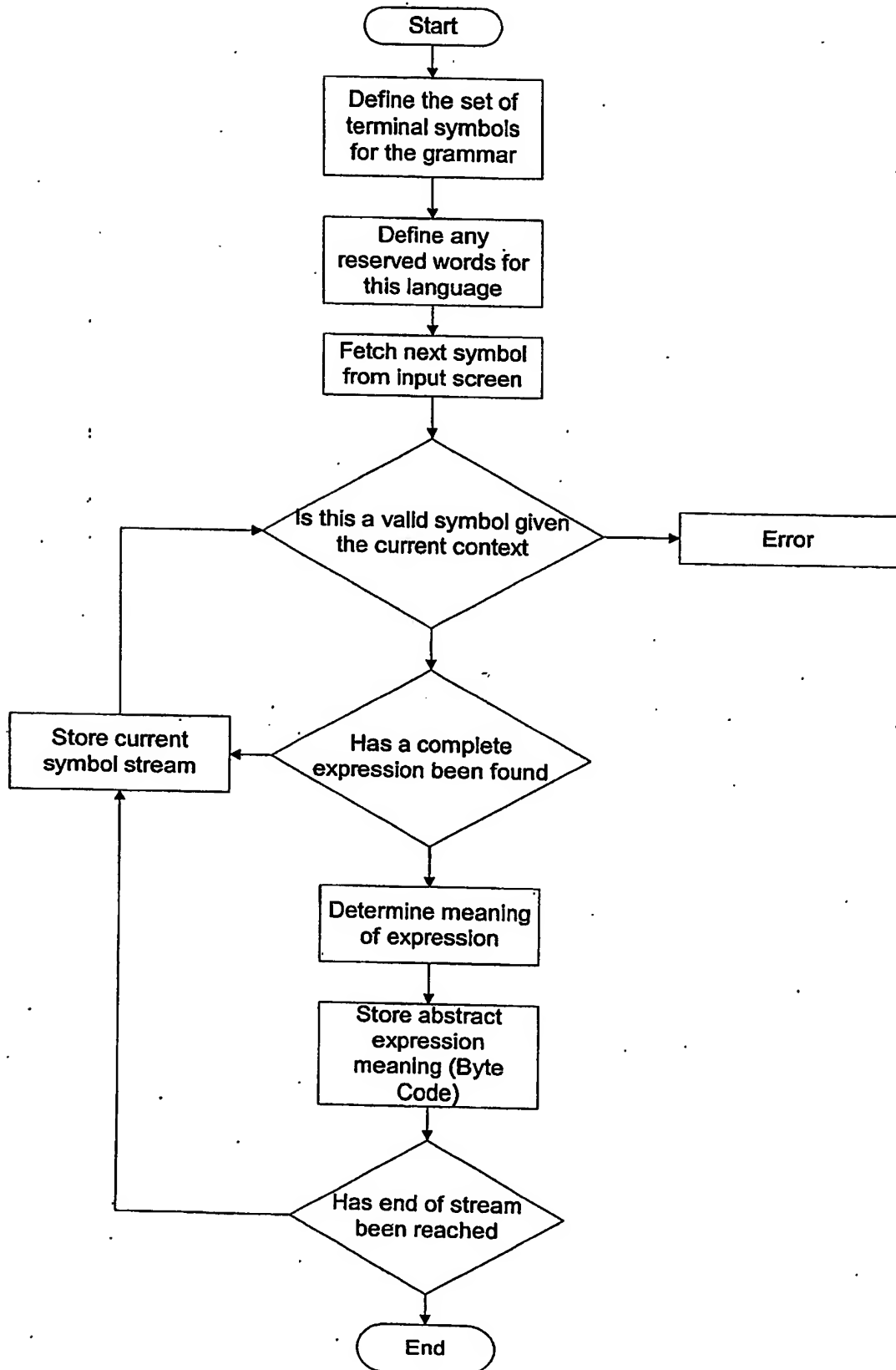


Figure 2

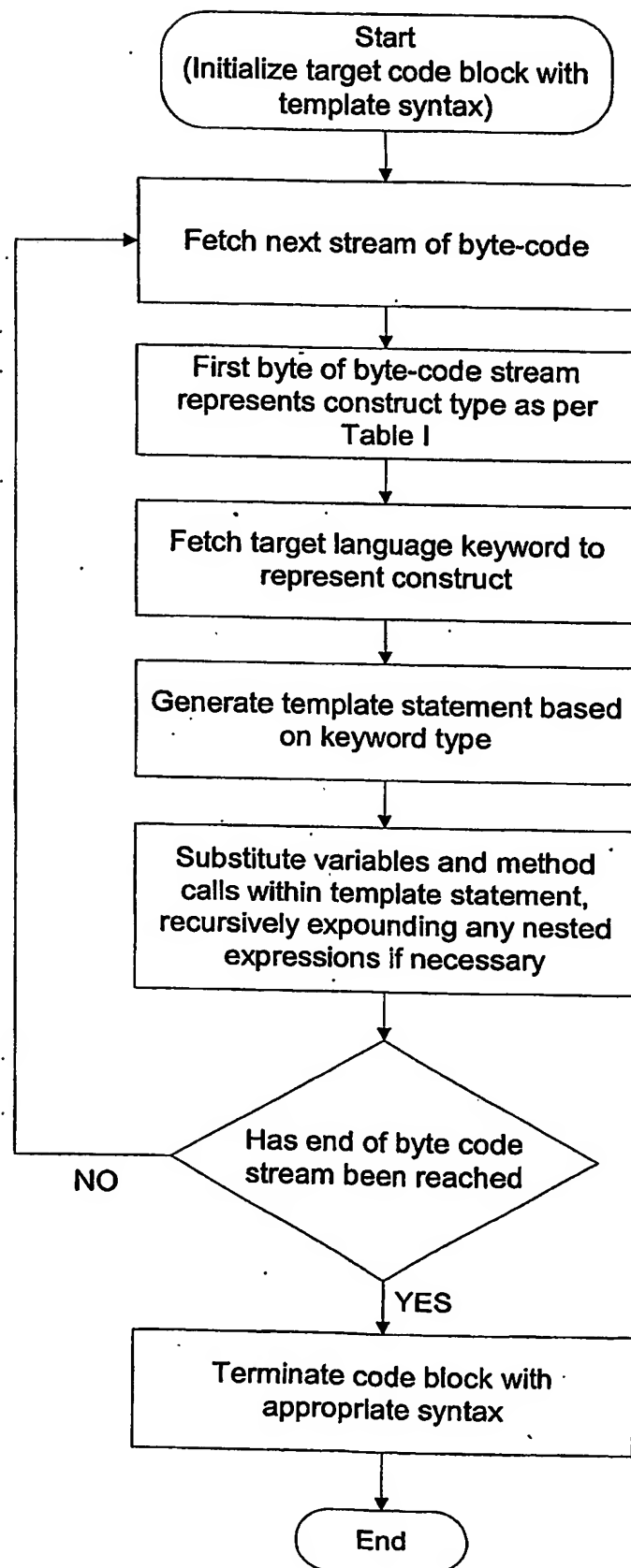


Figure 3

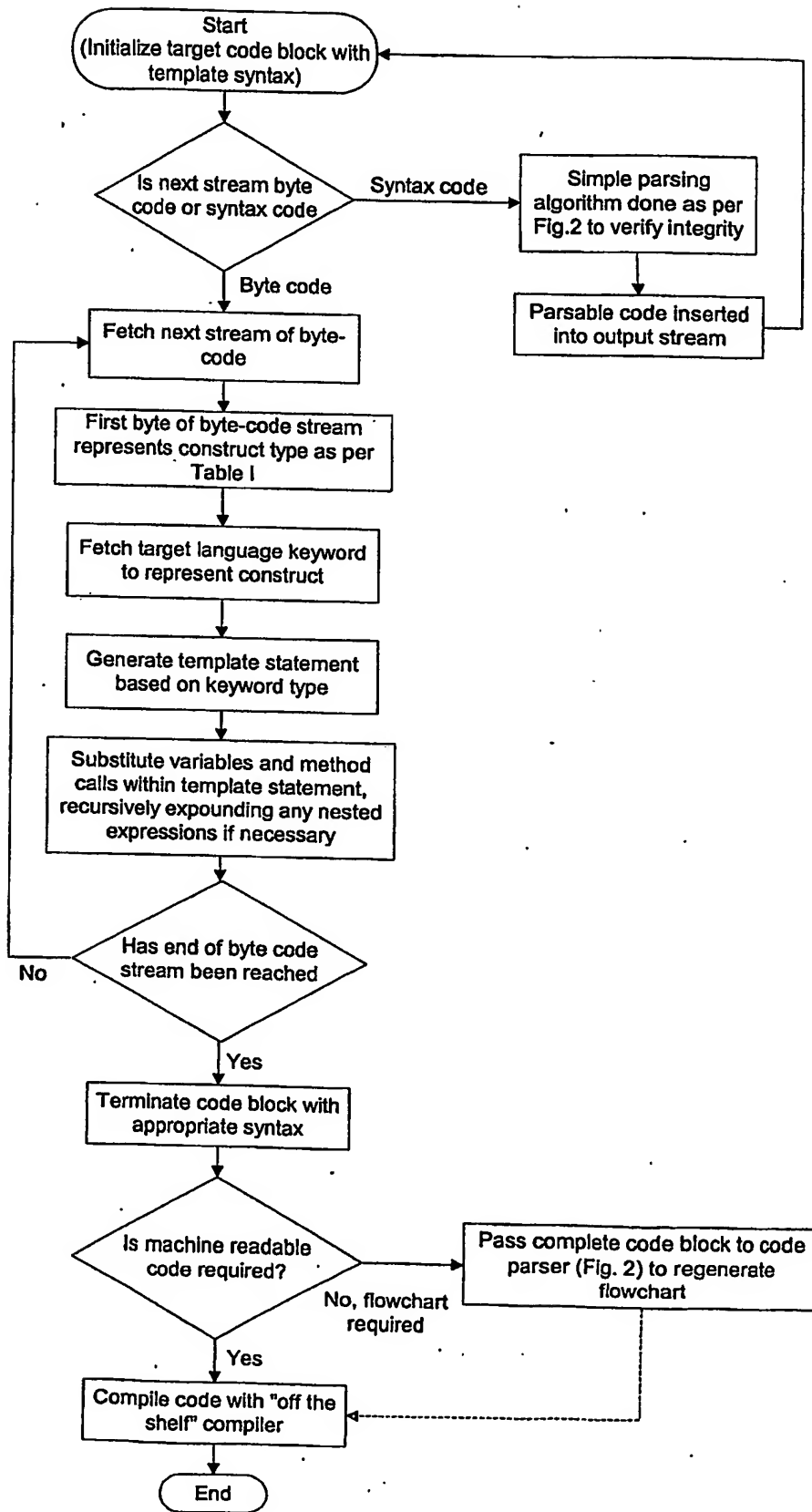


Figure 4

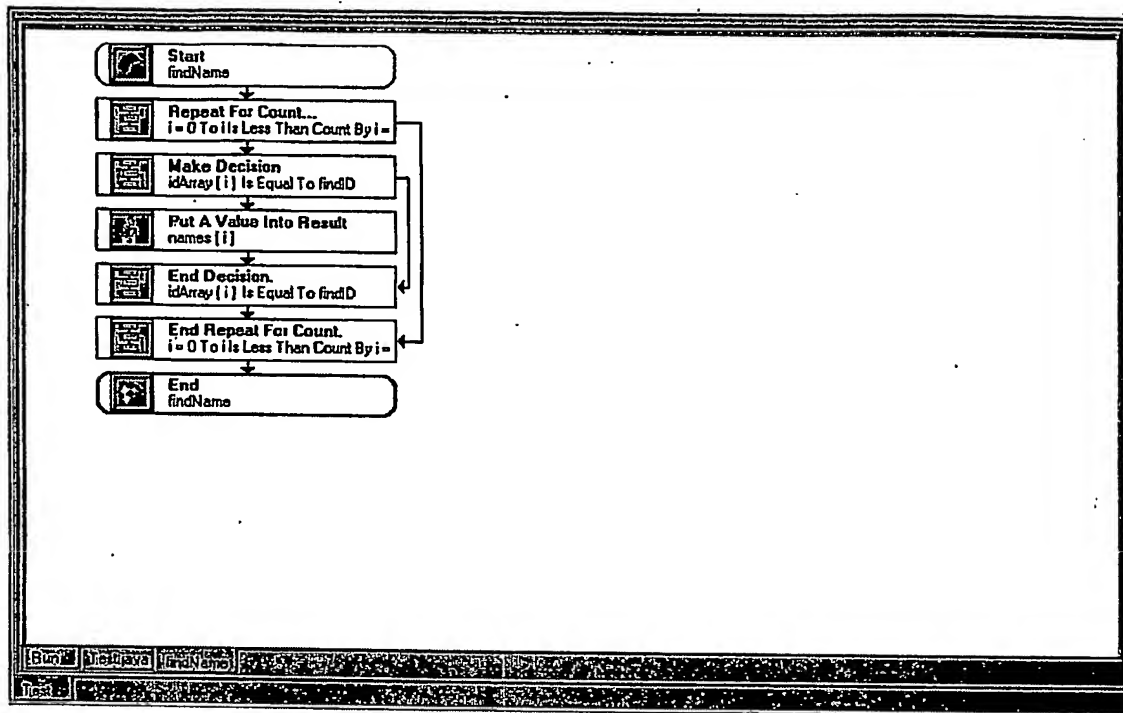


Figure 5

```
public String findName(int findID)
{
    String Result = "";
    try {
        int i = 0;
        for(i=(int) (0); i<this.Count; i=(int) (i + 1))
        {
            if(this.idArray[i]==findID)
            {
                Result=this.names[i];
            } // End If
        } // End For
    } catch(Exception ex){
        // TODO: custom exception handler
        ex.printStackTrace();
    }
    return(Result);
}
```

Figure 6

```
public String findName(int findID)
{
    String Result = "";
    try {
        int i = 0;
        for(i=(int) (0); i<this.Count; i=(int) (i + 1))
        {
            if(this.idArray[i]==findID)
            {
                Result=this.names[i];
            } // End If
        } // End For

        //Inserted Code
        if(Result.equals(""))
        {
            Result="<not found>";
        }
        //End of Inserted Code

    } catch(Exception ex){
        // TODO: custom exception handler
        ex.printStackTrace();
    }
    return(Result);
}
```

Figure 7

Global Symbols:

Id	Name	Scope	Type
#1	idArray	private	Array of int
#2	Count	private	int
#3	names	private	Array of String

Local Symbols:

Id	Name	Scope	Type
@1	Result	local	String
@2	findID	Parameter	int
@3	i	local	int

ByteCode:

bytecode	Equivalent Code
0x080x15 (@3=0;@3<#2;@3=@3 + 1) of Expression (in Hex)	//For-Loop: 0x15 is length
Count	// Initializer: i = 0
	// Condition: i IsLessThan
	// Step: i = i + 1;
0x030x0C (#1[@3]==@2) names[i]	//If Result IsEqualTo
0x120x0B (@1=#3[@3]) names[i]	//Set Value: Result =
0x04	//End If
0x09	//End For-Loop
	//byte code resulting from inserted Code
0x030x08 (@1=="")	//If Result IsEqualTo ""
0x12x12 (@1="<not found>") found>"	//Set Value: Result = "<not
0x04	//End If
inserted Code	//End of byte code resulting from

Figure 8

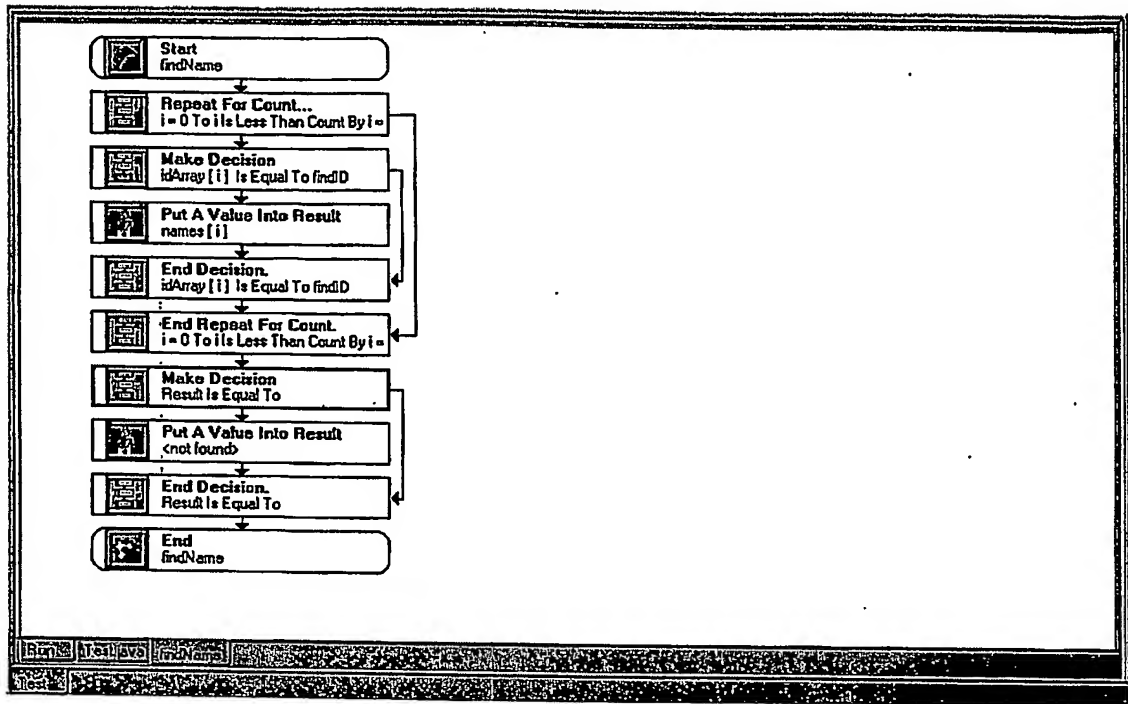


Figure 9

```
public String findName(int findID)
{
    String Result = "";
    try {
        int i = 0;
        for(i=(int) (0); i<this.Count; i=(int) (i + 1))
        {
            if(this.idArray[i]==findID)
            {
                Result=this.names[i];
            } // End If
        } // End For
        if((Result != null && Result.equals("")) || (Result == null && "" == null))
        {
            Result="<not found>";
        } // End If
    } catch(Exception ex){
        // TODO: custom exception handler
        ex.printStackTrace();
    }
    return(Result);
}
```